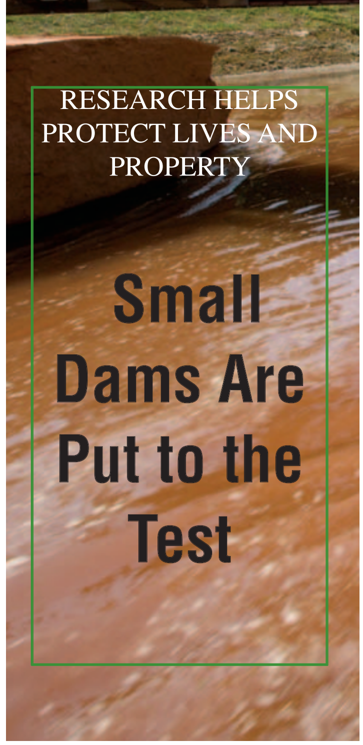


RESEARCH HELPS PROTECT LIVES AND PROPERTY

Small Dams Are Put to the Test

When hydrologists discuss why earthen dams fail, the conversation soon turns to a phenomenon called "overtopping."

"'Overtopping' is when water overflows the top of a dam. This may cause erosion of the earthen embankment, compromising its integrity," says Greg Hanson, a hydraulic engineer in ARS's Hydraulic Engineering Research Unit (HERU) at Stillwater, Oklahoma.

"It starts when water flow overwhelms storage and spillway capacities, be it due to inadequate or blocked spillways and pipes, extreme rainfall, large-scale snowmelt, or even landslide-generated waves," he says. "Overtopping causes about 35 percent of all U.S. dam failures."

Hanson says that about 57,000 of the 80,000 dams in the National Inventory of Dams have potential to overtop. "I'm speaking mostly about smaller, earthen embankments, many of which are right within communities," he says. "They range in height from a few feet to a couple hundred feet."

Almost half of these dams were constructed in 47 states with financial or technical assistance from USDA's Natural Resources Conservation Service (NRCS). These dams, which have an estimated value of $14 billion, protect lives, property, and infrastructure.

"Earthen dams in the United States have an admirable safety record," says Hanson. "But, for economic reasons, the risk of overtopping can never be fully eliminated. So our challenge is to determine, in advance, how well these embankments will perform if they overtop during a major flood."

Addressing an Aging Infrastructure

Concerns about overtopping are directly related to a larger issue that ARS is involved in through studies on water quality and management: aging of small dams. Mark Weltz of ARS's National Program Staff says many of the structures are near or at the end of their planned service life and will require extensive rehabilitation.

Hanson says that sediment buildup is a key age-related overtopping concern because it can reduce a dam's capacity. Also, he explains, residential or commercial development in upstream areas may contribute to extreme water flow that the dam was not originally designed for. Impermeable surfaces such as concrete, asphalt, and rooftops result in increased runoff that must be stored for flood protection.

"While many dams in the United States are being rehabilitated, there aren't enough resources available to get to all of them in a timely manner," says Darrel Temple, HERU's research leader.

"To help managers prioritize which dams need rehabilitation and what type is needed, we focus on computer technology that will simulate and evaluate specific overtopping scenarios. We're also improving our ability to collect data to feed into these computer programs."

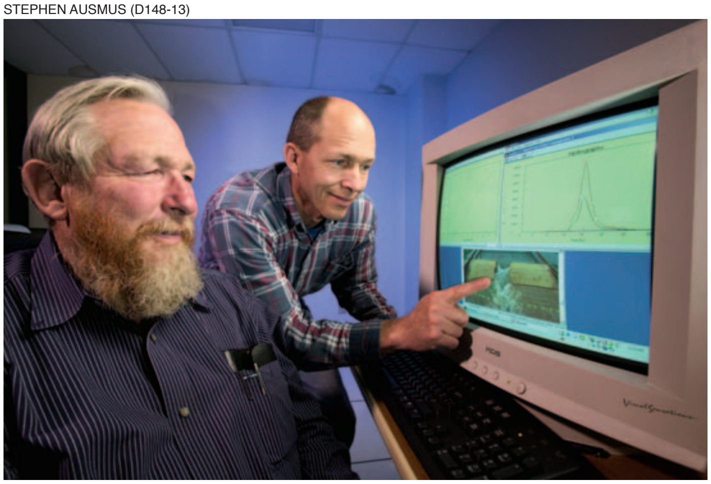
The experimental data and computer-model simulations help researchers anticipate waterflow and intensity of flooding in case of a breach and determine hazards, emergency procedures, and flood zoning.

"Accurate data helps us base the models on reality, allowing us to validate, calibrate, and test them so they'll give accurate predictions of when earthen dams may fail," says Temple.

A Myriad of Scenarios

Of paramount importance at HERU is studying how high hydraulic stress affects small dams and related infrastructures. This unique laboratory, established in 1940 on 100 acres downstream of Lake Carl Blackwell, enjoys worldwide acclaim for contributions to design criteria for structures and channels affecting soil and water conservation. The lab's scientists create a myriad of

STEPHEN AUSMUS (D148-13)



Hydraulic engineers Darrel Temple (left) and Greg Hanson work on combining SIMBA (Simplified Breach Analysis) with WINDAM (Windows Dam Analysis Modules) to simulate stages of the dam-breach process.

STEPHEN AUSMUS (D147-28)

From an observation platform overlooking a test dam, Greg Hanson records the test for use in computer modeling.

STEPHEN AUSMUS (D144-6)

Hydraulic engineers Greg Hanson and Sherry Hunt view the start of a headcut-widening test, which will help them understand the widening component of the dam-breach process.

hydraulic-stress scenarios—both indoors and outdoors—using large-scale outdoor flumes, structures, and artificial channels. They also use four buildings designed to accommodate physical models of landscapes and flowing water.

In addition to physical testing in which overtopping scenarios are evaluated, Hanson, Temple, and other scientists there have, over the past 5 years, created and improved several computer models for analyzing and predicting extreme-event dam performance.

They started by studying erosional failures in grass-lined emergency spillways—work that led to a three-phase, earth-spillway erosion computer model. This model became part of NRCS's water resource analysis software, called SITES. (SITES software can be downloaded at www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-sites.html.)

HERU's latest computer-related work involves the SIMplified Breach Analysis (SIMBA) model—a descendant of the earth-spillway erosion simulation. The researchers are also working to develop WINDAM (WINdows Dam Analysis Modules), an analysis routine for use on small dams that are subject to overtopping.

Temple says SIMBA reproduces key features observed in tests of embankment dam failures. The model divides the dam-breach process into four stages, recognizing that more than one type of erosion may be dominant during a given stage.

Currently, SIMBA only analyzes simple embankment conditions—those with just one type of soil. "It's research oriented, but we're working to incorporate it into WINDAM," Temple says.

Once fully operational, it will show how much time elapses between each of the four stages of the breach process. It will also provide technical graphs, or data plots, of water elevation in the reservoir, rate of water leaving the reservoir, and time from when water first overtops the dam to when the dam could fail. This information could be used to determine which homes, businesses, or roadways should be evacuated and how much time would be available to leave in case of a flood.

Keying In on the Data

Data acquisition was a key element of recent tests Hanson led in Stillwater and in Europe, where he was part of a research-exchange project involving large- and small-scale physical models.

In Stillwater, Hanson and Temple conducted large-scale studies on headcut migration and how breaches start, form, and widen. As part of the European work, Hanson assisted in 23 small-scale tests conducted in England and 7 tests in Norway on 20-foot-high embankment dams of different designs.

These tests were part of two endeavors. One was funded by the Research Council of Norway and the other by the European Union as part of its IMPACT project.

The small-scale testing was done at H.R. Wallingford, a British firm that researches civil engineering hydraulics and the water environment. The large-scale field tests were done near Mo I Rana, Norway, just downstream of a large dam.—By **Luis Pons,** ARS.

This research is part of Water Quality and Management, an ARS National Program (#201) described on the World Wide Web at www.nps.ars.usda.gov.

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